Combined short- and long-term heat storage with Sodium Acetate Trihydrate for solar heat supply in buildings

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Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

COMBINED SHORT- AND LONG-TERM HEAT STORAGE WITH SODIUM ACETATE TRIHYDRATE FOR SOLAR HEAT SUPPLY IN BUILDINGS

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Background:

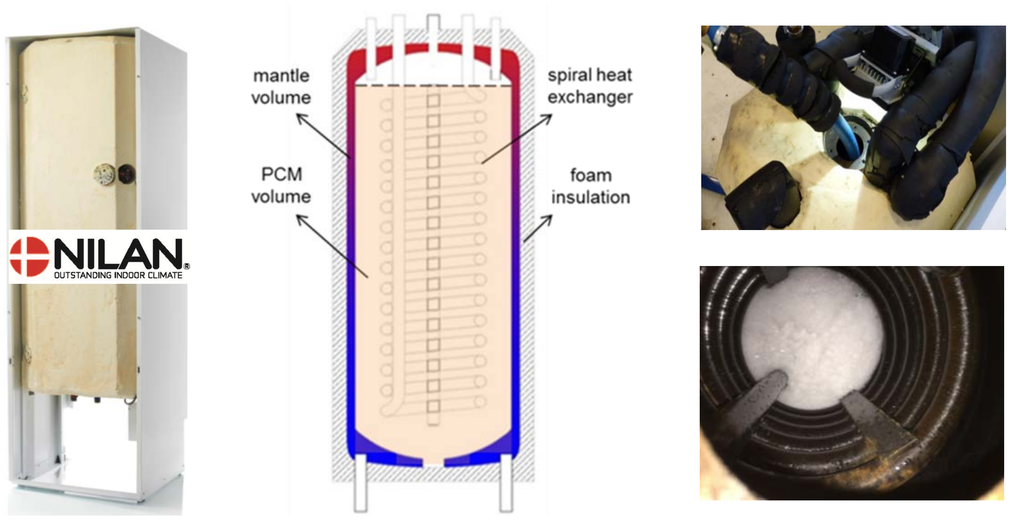
Due to the mismatch of solar energy resources and domestic heat demand, long-term storage of heat is essential for an innovative system with a high solar fraction in the range of 70%-100%. Therefore a concept based on stable supercooling of a sodium acetate trihydrate (SAT) has been investigated.

Material properties:

- Melting temperature: 58 °C
- Latent heat of fusion: 264 kJ kg^{-1}
- Market prices (food grade): typically below 0.5 € kg^{-1}
- Thickening agents and liquid polymers are used to stabilize SAT
- SAT can supercool to ambient temperature while heat of fusion is preserved

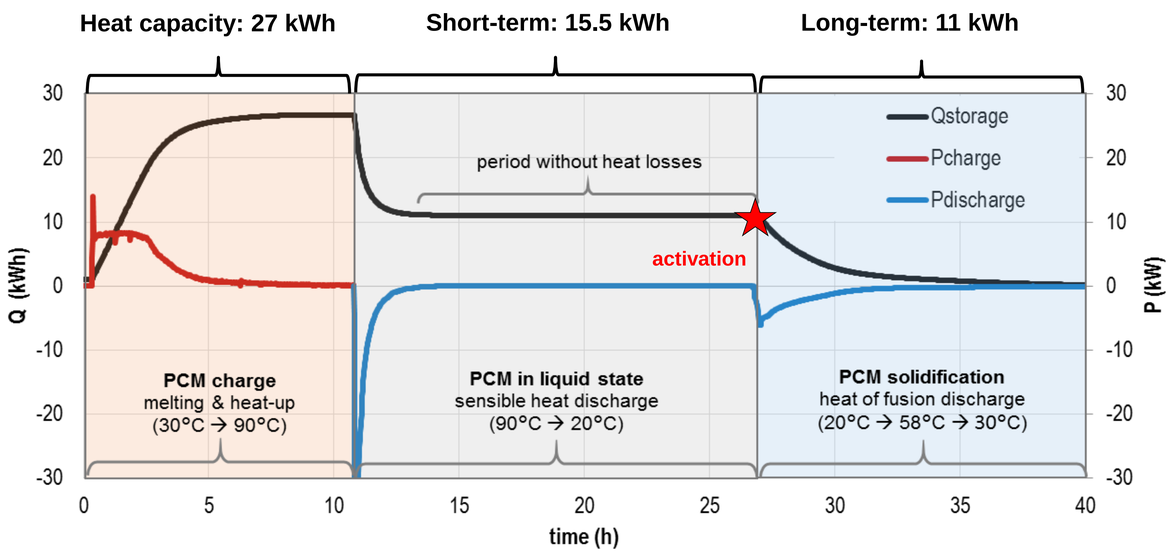
Heat storage units:

Supercooling of SAT composites can be achieved in flat container of 150 L with an internal height of 5 cm. Later, a cylindrical container (Ø 0.4 m) of similar volume was built with an internal spiral heat exchanger. It was situated in a water tank (Ø 0.46 m) so that heat transfer via its outer surface was possible. The total heat exchange surface was 3 m^2. Units of both design were constructed by Nilan A/S.



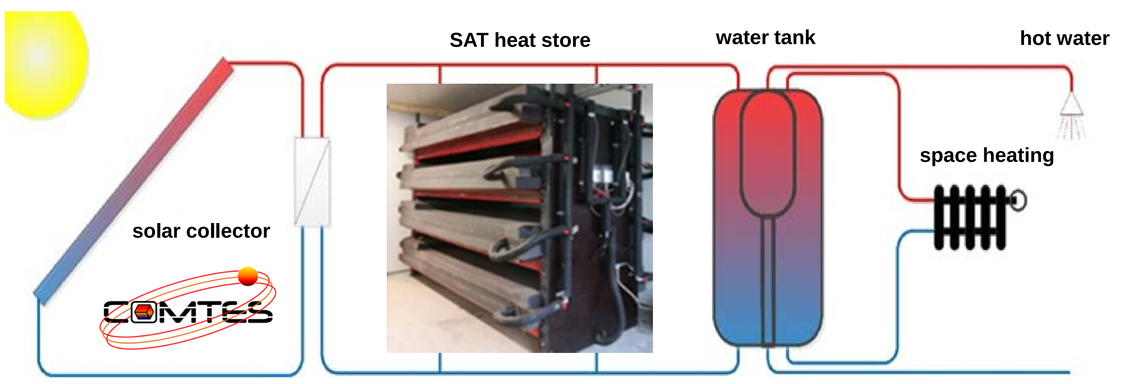
Potentially inexpensive heat storage design

Prototype units were tested for their short- and long-term heat storage potential after heating to 90 °C. Controlled activation of SAT crystallization was achieved by either seed crystal injection or local cooling (CO_2 evaporation, Peltier elements).



Test results of cylindrical heat storage unit

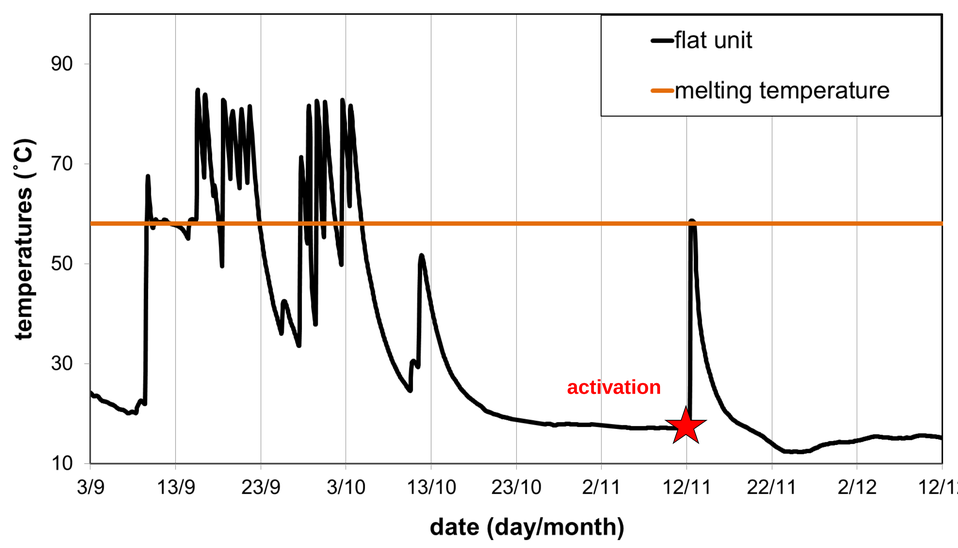
Demonstration system:



Solar combi-system with segmented SAT heat store

A segmented SAT heat store was formed by 4 flat units. 22.4 m^2 of evacuated tubular collectors were installed. Hot water and space heating demand was drawn-off at the 750 l water tank. Flat units were charged after the water tank was heated up. Heat transfer from the SAT units to the water storage in periods with shortage of solar energy.

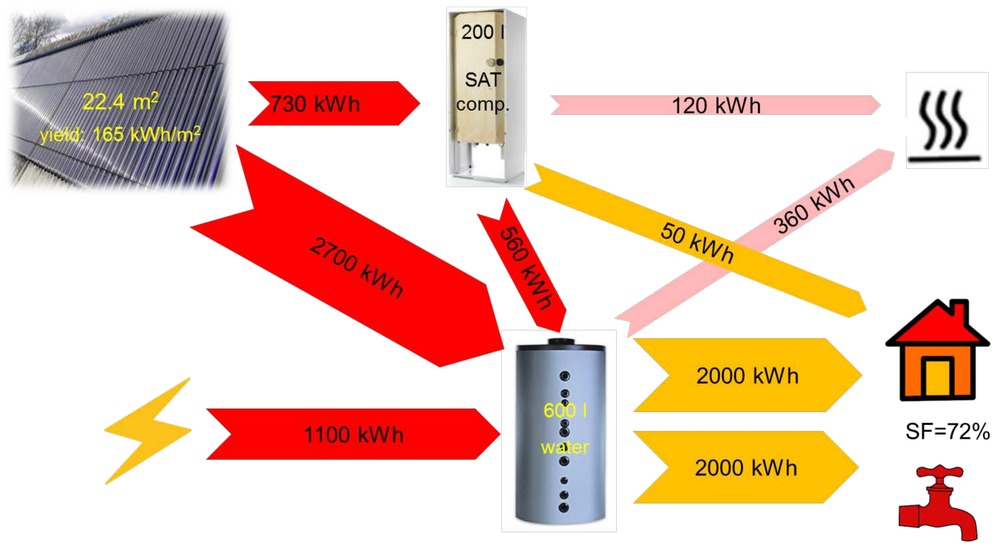
In autumn SAT composite remained up to 2 months in supercooled state:



Proof of concept

System simulation:

- Component models were developed and experimentally validated
- Daily hot water demand: 126 L at 45 °C (3 persons)
- High Solar Fractions (SF) for a Passive house in Danish climate



Yearly heat flux (supply, demand, loss) in the solar combi-system

Acknowledgement:

This research is funded by the PhD program of the Sino Danish Center for Education and Research (SDC). The work was also supported by the European Commission (Grant Agreement N_295568). We would like to thank our industrial partner NILAN A/S for the good collaboration.

Conclusions:

- **Proof of combined short- and long term heat storage**
- **Improved cylindrical units are potentially economic**
- **Application of segmented heat stores in novel energy systems:**
  → Power to heat (PV, wind power) → Solar combi-system 2.0